DESIGN OF PEDESTRIAN WALKWAYS WITH SOLAR PANEL ROOFING IN SAN JOSE DEL MONTE NATIONAL TRADE SCHOOL, CITY OF SAN JOSE DEL MONTE, BULACAN

A Quantitative Research

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Bachelor of Science in Civil Engineering

Major in Construction Engineering

and Management

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RECOMMENDATION

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This is to certify that this research paper was originally made by the researchers and does not contain any material previously published or written by another person nor material to a substantial extent of being accepted for an award or any degree of diploma in La Concepcion College and other educational institutions except where due acknowledgement is made in the research paper.

We also declare that the intellectual content of this research is a product of our own effort, conceptualization, and brainstorming in aiming to improve certain problem of our society. Any contributions made to the research of others is explicitly acknowledged in this paper.

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CHAPTER 1

The Problem and Its Background

This chapter presents an overview of the study including the introduction, background of the study, theoretical framework, conceptual framework, statement of the problem, hypothesis, scope and limitations of the study, significance of the study, and definition of terms.

Introduction

Pedestrian walkways are vital to the safety of the public, especially for students located near the vicinity of the school. In designing these structures, it is very important to ensure their functionality, sustainability, and safety. It must comply with the standard where pedestrians feel safe and secure in using it by providing a design accessible for them. It must help in the cleanliness of the environment through its proper drainage system. Unfortunately, in the Philippines many of these existing walkways are not being used properly and not serving its purpose. Some structures do not comply with the standard design for its intended use therefore, the public chose not to use it. It may also imply a proof of no clear plans and simply creating a design for the sake of publicity. One of the best examples is the existing pedestrian walkways in San Jose del Monte National Trade School, City of San Jose Del Monte Bulacan.

This research is in a city beside the highway and several schools. It is a busy road with a lot of commercial buildings like food stalls, convenient stores, and a

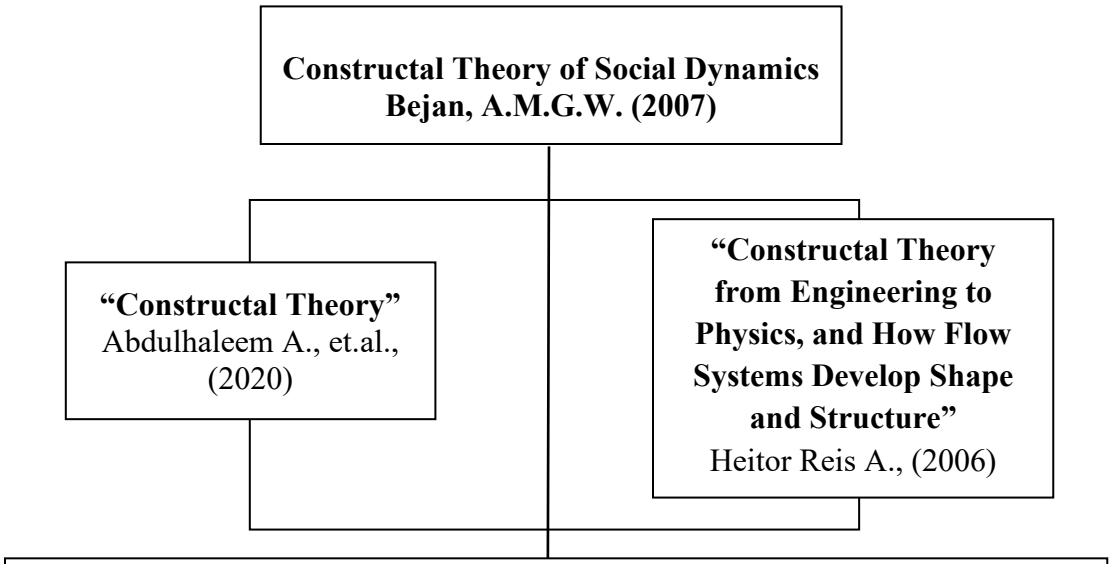
gasoline station. It is a place expected to have a lot of people walking and wandering around. With, it is observed that the pedestrian walkway between the main road and school is not quite accessible because of the structure itself. Proper lighting during nighttime is also inadequate. This study aims to enhance its design for safety and functionality.

Background of the Study

Design of Pedestrian Walkways with Solar Panel Roofing in San Jose Del Monte National Trade School is a research to design eco-friendly and aesthetically pleasing pedestrian walkways with solar panel roofing which would be beneficial to the road users. The researchers' objective is to come up with a highly functional walkway for the public, especially for students, following a standard for safety and comfort and aims sustainability for the environment as it may help reduce global warming using solar panels. These solar panels help supply electricity that may be used during night time to avoid incidents of crime in the vicinity.

The existing pedestrian walkways in San Jose Del Monte National Trade School have an inadequate design due to the slope of the road and land. It shows a lack of surface drainage system which results in ponding at the portion of the walkway as well as the absence of railings for elevated parts. Due to inaccessibility, pedestrians use the main road instead of the walkway, leading to overcrowding, traffic, and safety risks. The study focuses on improving the walkway's design and drainage system to enhance sustainability, ensure public safety, reduce congestion, and accommodate persons with disabilities

Theoretical Framework


Constructal Theory of Social Dynamics
Bejan, A.M.G.W. (2007)
"Constructal Theory"
Abdulhaleem A., et.al.,
(2020)
"Constructal Theory from Engineering to Physics, and How Flow Systems Develop Shape and Structure"
Heitor Reis A., (2006)

Constructal Theory of Social Dynamics is a theory that is a guide and basis of our research project. It is a theory which explains that configuration is one of the major challenges in design. It shows ideas that better designers make choices that work like configurations that have been tested for instance. These are some of the main ideas that our research would like to focus on. It is about an existing walkway that is being tested by its effectivity and efficiency. It helps us understand that experience and longevity are useful when the needed system is envisioned as an assembly of already existing parts. In our research it is crucial to determine the longevity of the existing walkway. It helps us understand how to create a useful structure. It also presented several useful strategies for discovering architectural features that lead to more promising configurations, and ultimately to better optimized designs. The Constructal Theory also explained pattern formation in nature and pedestrian motion. This pedestrian motion is one of the main highlights of our research project because it is affected by factors such as design and safety of walkways. It helps us understand that pedestrian crowd motion exhibits variety of patterns, we want to create a change from a chaotic appearance to spontaneous organized lanes of uniform walking people. Constructal Theory contributes significantly to our research connecting people's behavior and employing the process of creating or enhancing structural efficiency and performance.

Figure 1: *The theoretical framework illustrates theories from different studies*

IPO Conceptual Framework

INPUT	PROCESS	OUTPUT
1.0. How can road users ensure their safety and accessibility in the area in terms of: 1.1. Gender 1.2. Students 1.3. Teachers 1.4. Residents 1.5. Motorists 1.6 PWD 2.0. How can the traffic be reduced for safety and accessibility in terms of: 2.1. Slope 2.2. Width 2.3. Surface material 2.4. Presence of railings 3.0. How can the drainage systems affect walkways' performance in terms of: 3.1. Pond prevention 3.2. Concrete erosion 4.0. How does the assessment of walkways with solar panel compared to the traditional walkways be in terms of: 4.1. Sustainability 4.2. Scheduling 4.3. Cost-effectiveness 4.4. Energy 5.0. How can the design of structural roofs affect their performance to prevent failure in terms of: 5.1. Dead load 5.2. Live load 5.3. Wind load 5.4. Seismic load	● Design pedestrian walkways based on their standard slope and width. Provide railings and appropriate surface materials. ● Design a drainage system considering its slope and materials. ● Cost estimation ● Computation of energy consumption (LED outdoor wall lights and cell phone charger), solar panel needed, battery, inverter and charge controller size ● Collect, analyze and interpret data gathered. ● Conduct a test on roof's load through STAAD pro.	

Statement of the Problem

Walkways are created for the safety of people, especially for students if they are located near the vicinity of the school. The pedestrian walkways in San Jose del Monte National Trade School, City of San Jose del Monte Bulacan, is an example of an inadequate design particularly in the drainage system and lack of protection barrier for elevated parts. Because of inaccessibility, people would rather choose to use the main road which may result in overcrowding, causing more traffic and posing possible risk.

This study seeks to address the following research questions:

1.0. How can road users ensure their safety and accessibility in the area in terms of:

- 1.1. Gender
- 1.2. Students
- 1.3. Teachers
- 1.4. Residents
- 1.5. Motorists
- 1.6 PWD

2.0. How can the traffic be reduced for safety and accessibility in terms of:

- 2.1. Slope
- 2.2. Width
- 2.3. Surface material
- 2.4. Presence of railings

3.0. How can the drainage systems affect walkways' performance in terms of:

3.1. Pond prevention

3.2. Concrete erosion

4.0. How does the assessment of walkways with solar panel compared to the traditional walkways be in terms of:

4.1. Sustainability

4.2. Scheduling

4.3. Cost- Effectiveness

4.4. Energy

5.0. How can the design of structural roofs affect their performance to prevent failure in terms of:

5.1. Dead load

5.2. Live load

5.3. Wind load

5.4. Seismic load

Objective of the Study

The researchers' goal is to design enhanced pedestrian walkways in San Jose del Monte National Trade School, City of San Jose del Monte Bulacan. The focus is mainly on the improvement of the structure and the addition of solar panel roofing.

Specifically, the objectives of this research are as follows:

1.0. To determine the demographic profile of the respondents and ensure the safety and accessibility in the area in terms of:

1.1. Gender

1.2. Students

1.3. Teachers

1.4. Residents

1.5. Motorists

1.6 PWD

2.0. To evaluate how traffic is reduced for the safety and accessibility of the public in terms of:

2.1. Slope

2.2. Width

2.3. Surface material

2.4. Presence of railings

3.0. To examine the drainage systems that affect walkways' performance in terms of:

3.1. Pond prevention

3.2. Concrete erosion

4.0. To assess construction of walkways with solar panel compared to the traditional walkways be in terms of:

4.1. Sustainability

4.2. Scheduling

4.3. Cost- Effectiveness

4.4. Energy

5.0. To analyze the design of structural roof that affects its performance to prevent failure in terms of:

5.1. Dead load

5.2. Live load

5.3. Wind load

5.4. Seismic load

Hypothesis

H_0: The enhanced design of pedestrian walkways in San Jose del Monte National Trade School, City of San Jose del Monte Bulacan has no significant effect on pedestrians' safety and electricity conservation.

H_a: The enhanced design of pedestrian walkways in San Jose del Monte National Trade School, City of San Jose del Monte Bulacan has a significant effect on pedestrians' safety and electricity conservation.

Significance of Study

The result of the study is of substantial help with the following issues:

Traffic Congestion: In the absence of pedestrian walkways, pedestrians walk in the middle of the road causing traffic congestion, especially in hours when students come and go to school. An effective design of walkways may allow people to use it more rather than walking along the streets and this will result

in smoother traffic flow.

Accident and Crime: High records of accidents happen in the street where people are hit by motorists due to the absence of a proper walkway. But with the use of an effective walkway accident may be less as fewer individuals walk in the middle of the road. Accidents and crime also happen during night in the absence of proper lighting in dark portions of the road. But if there is enough light in those areas, criminals may have caused less crimes.

Energy Conservation: Electricity bills have been getting higher for the past few months. The government is spending so much on electricity consumption on public highways. Therefore, electricity produced using solar panels is highly beneficial for the government as well as the community. The people near the walkways may also have free access to charging stations. Passengers who are caught in the middle of the rain may also charge their phones, especially in times of emergency.

Future researchers: This study may serve as a future reference for other researchers who wish to study any topics related to an effective pedestrian walkway, and how to effectively use solar panels as well as proper drainage systems.

Scope and Limitation

This research focuses on the effectiveness of pedestrian walkways with proper drainage system and solar panel roofing. Events like typhoons, and calamities related to such are not included in this study. The researchers restricted the extent of walkways

design with its drainage system and railings, and the use of solar panels.

The proponents chose San Jose Del Monte National Trade School in the City of San Jose Del Monte, Bulacan as the location of study for this area is very visible to the public and is observed to show traffic congestion in times where students come and leave the school. It is a pedestrian walkway located along three adjacent schools such as: San Jose del Monte National Trade School, Sapang Palay National High School which are known as a very large school in terms of its population, together with Colegio De San Gabriel Arcangel school. This research is limited to the location of San Jose Del Monte National Trade School, as the researchers will conduct surveys among students and residents nearby who will benefit from it.

Definition of Terms

Accessibility- is the concept of whether a product or service can be used by everyone, however, encounters it. It aids people with disabilities, accommodate all potential users.

Concrete Erosion- the gradual breakdown of the concrete surface due to factors like abrasion from solids, liquids, or air bubbles in motion, as well as chemical attacks by acids or salts.

Dead Load- refers to a structure's static, non-moving weight or any permanent components that form an integral part of it. It primarily consists of the weight of the building materials and any fixed installations, such as walls, beams, columns, roofs, and flooring.

Drainage System- involves the removal of surface and subsurface water from an area

through well-defined pipeline connectivity or channels

Enhancing- to increase or improve in value, quality, desirability, or attractiveness.

Functionality- the quality of being useful, practical, and right for the purpose for which something was made.

Inadequate Design- including poor material selection, faulty components, or insufficient stability features.

Live Load- refers to the transient or moving loads that structures experience due to human occupancy, furniture, vehicles, and other temporary factors.

Pedestrian Walkways- is any type of defined space or pathway for use by a person traveling by foot or using a wheelchair.

Ponding- is the unwanted pooling of water, typically on a flat roof or roadway.

Seismic Load - refers to the force or shaking that a structure experiences during an earthquake.

Solar Panel- is a device that converts sunlight into electricity by using multiple solar modules that consist of photovoltaic (PV) cells.

Sustainability- is the ability to maintain or support economic, environmental, or social processes over time without depleting natural resources.

Traffic Congestion- occurs when the number of vehicles is larger than the capacity of a road or intersection. As a result vehicles pile up, velocity decreases and trip time increases.

Wind Load- is essentially the wind pressure or wind force, in pounds per square foot, exerted on a building.

CHAPTER 2

Review of Related Literature and Study

This chapter contains a review of related literature and studies done by other local and foreign researchers. Those related studies included in this chapter aid in familiarizing relevant and related information to the current study.

Foreign Literature

In building the Design for pedestrian walkway Solar Radiation is one of the challenges that might encounter in pedestrian performance comfort. However, innovation in design planning provides a definite solution to balance the heat and comfort.

According to Tomasi et al. (2023), solar radiation is a critical variable in outdoor thermal comfort because it affects the heat balance of the body. This is relevant when promoting outdoor activities. The researchers 15-minute city concept argues for comfortable and safe walking environments. Because of world population growth and urbanization trends. The number of people that would benefit from comfortable urban pedestrian paths is increasing. Therefore, highlighting the accessibility and design of the pedestrian through solar panel roofing could enhance the pedestrian comfortability.

Same with the submitted article of Rodrigues et al. (2024), it said that energy has been the focus greatly on research that attributed to the economy, climate change

and political decisions. From one standpoint, countries want to ensure energy independence and security relative to other nations, competitiveness, and economic standing. However, it is necessary to reduce the emissions of carbon dioxide (CO2) and greenhouse gases to mitigate climate change. The researchers introduce some solutions that allow for the achievement of energy sustainability, which can be defined as "the provision of energy such that it meets the needs of the present without compromising the ability of future generations to meet their needs". In addition to reducing energy demand, energy sources in the energy mix need to be diversified and energy production from renewable sources needs to be increased.

The integration of the structure and solar panels have different innovative approaches to achieve sustainable infrastructure. In terms of pedestrian walkway, Solar panel roofing not only provides safety to solar radiation and improves the comfort of the users, it could also generate solar energy that could support lighting.

In the stated literature of Rahardo et al. (2024), the rapid development of science and technology has brought us into a new era where environmentally friendly and sustainable infrastructure development has become the primary focus in various sectors, including pedestrian pathway planning. Universities play a crucial role in promoting environmental sustainability as centers of knowledge. One significant aspect of creating a suitable campus environment is providing safe and comfortable pedestrian pathways. As a global response to environmental issues, encouraging the utilization of new renewable energy that is more environmentally friendly, where solar power plants have become an alternative energy source that is environmentally

friendly and sustainable.

Therefore, this emphasized the design should be according to the safety of the users. The Proper pedestrian pathways offer several benefits to all users such as improved physical and mental health, transportation efficiency, and increased satisfaction and happiness.

According to Tomasi et al. (2024), shading pedestrian paths is strategically important to ensure accessibility and comfort for pedestrians in cities. Tomasi said that solar radiation is a key climatic variable in outdoor contexts, as emerged in assessing thermal indexes. Especially under clear sky conditions, solar radiation has a large impact on the human heat balance. So therefore, to foster a better environmental quality we used canopy as solution material for shading in the design of structure. Tomasi proposes a workflow to design effective installations of shading devices on sidewalks; it relies on a design tool developed prioritizing compatibility with other processes for its application to urban design. The methodology was tested in the city of Milan. Based on solar radiation exposure of urban canyons, a time of the day was associated with each simulated summer scenario.

In the pedestrian walkway, properly planned drainage systems are vital in designing an infrastructure. Having an unplanned design might harm the users and the structure itself. It may lead to structural erosion and water ponding.

According to Chu et al. (2023), the researchers stated that a comprehensive understanding of drainage methods and their effectiveness can facilitate pavement drainage design. Thus, a selective literature review was conducted to demonstrate

subgrade moisture variation and pavement drainage methods. The subgrade moisture variation was evaluated based on previous studies from three aspects: field investigation, drainage simulation and laboratory studies. Subsurface drainage methods were summarized, and some examples were demonstrated. Drainage effectiveness and its influencing factors were analyzed to clarify their hydraulic and mechanical effectiveness.

Local Literature

Pedestrian walkways are a very accommodating part of a structure, not just a structure, but they also turn it into very different ways to use them. Usually, some areas, especially in urban cities, don't usually build a pedestrian walkway. Instead, they just rely on the footpath or sidewalk.

According to Diaz et al. (2021), roads in the Philippines should have myriad pedestrian walkways that can benefit and help the communities. The government, on the other hand, lacks resources and skills to identify and to build a pedestrian walkway. Diaz also stated that other resources should not be wasted on other unappropriated projects. Instead, local officials should focus on establishing and changing public roads and pedestrianization. This article talked about the planning and designing of a pedestrian walkway for better and organized accessibility for others. They also stated that, if possible, there should be closed roads only for pedestrians, only for pedestrians and not for vehicles for more safety and more pedestrian friendly. The pedestrian walkway is not just aesthetics or a waste of resources or location. The pedestrian walkway is established to make sure the pedestrians are safe in their transportation,

and it also has a huge impact and name on our country if it is gaudy, accessible, and safe for the citizens.

Solar panels are devices that can solve the crisis of energy shortages in the state and are still improving today by incorporating various features. Solar panels not only reduce electricity consumption; they also save a lot in terms of electricity bills, which is a main problem in the Philippines.

According to Dellosa et al. (2021), solar power has multiple benefits and can enhance our economy by building and multiplying solar power systems in the Philippines, having a huge impact and working very well in the country. Solar panels are not just for energy savings or reducing bills; they also help reduce pollution in the country by cutting down carbon emissions that are usually present in burning fossil fuels to distribute energy. Including solar panels in our infrastructure can improve electricity consumption and enhance the aesthetics of that infrastructure.

According to Levosada et al. (2022), solar power plants need a suitable area to generate a myriad of energy. They used Geographic Information System (GIS) and Analytical Hierarchy Process (AHP) to find a specific suitable area for solar power plants. The location of solar panels should be determined for better energy generation compared to being unplanned. Solar panels can potentially improve the economy and lifestyle of the country if there is proper planning and an understanding of how solar power works, as well as the geography where they are located, to ensure that the quality of the solar panels is in very good condition and not lacking in any regard.

Modern society and country growth can cause instability for the roads, especially in terms of traffic. The measure of how many vehicles are on the roads is one of the main problems of traffic in the country, along with the structure and functionality of the roads. Roads are the pathways for vehicles; when a road is unstable, poorly functioning, and not well-designed, that's why traffic in some areas of the country will never solve the traffic problem.

According to Aydinan (2020), study in Cabanatuan City, Nueva Ecija, explored how traffic affects the economy and the daily lives of citizens. They found that poor road maintenance, weak traffic control, lack of proper infrastructure, and overcrowding of vehicles are the main reasons why some areas in the city are the most congested. The study stated that road repairs and maintaining law enforcement should be prioritized to reduce traffic and to ensure that the roads are completely usable and accessible in case of emergency or other reasons. Maintaining and making it accessible, this research shows that the importance of accessibility should be prioritized in any circumstance. Building a pedestrian walkway should help pedestrians ensure their safety and reduce traffic in specific areas. Our research produces an accessible and better design and planning for pedestrian walkways to ensure that traffic and crowding in specific areas are reduced and for safe, clean, and pedestrian-friendly roads.

Everyone in society should prioritize their needs and safety, including the elderly and people with disabilities. When using transportation, they have benefits to claim, such as discounts on any transport, but when they rely on walking, they can't

feel that their needs are met, and the level of comfort on the road is minimal. The designs and paths they use are usually not compatible with their needs; that's why they are reluctant to walk outside their shelters and prefer vehicles for transport, which can also cause vehicle overcrowding.

According to Cervania et al. (2025), everyone should be free to walk outside without feeling uncomfortable for their safety and not being overlooked. The roads that are typically established are not disability- friendly and were not even planned to include pedestrian walkways for them. Cervania et al. established a strong foundation to ensure that pedestrian walkways are prioritized and accessible for everyone, so no one is left behind regarding walking and basic transportation.

We conclude that designing and planning a pedestrian walkway should follow the needs of all citizens, not just those who are ordinary or strong. Everyone should be able to use any infrastructure easily and access it without any problems. This research establishes a user-friendly design that everyone can access and use when utilizing the pedestrian walkway.

Foreign Study

The study by Kim et al. (2024), indicates that pedestrians are the most vulnerable road users to potential dangers, which is a key concern that should be addressed when designing pedestrian walkways. This study also suggests that not only safety but also the comfort of pedestrians should be considered

Eboli et al. (2023), explain the weaknesses of walkways, often resulting from a lack of shade, benches, and proper lighting, which make pedestrians uncomfortable.

The study utilized both objective data and subjective opinions to gather pedestrians' experiences regarding the existing walkways in Southern Italy.

Aghabayk et al. (2020), studied how proper slope for pedestrian walkways impacts users; in fact, it plays a very important role in designing the appropriate slope for pedestrian walkways. Comfort, even for people with disabilities (PWD) with a standard slope, ensures they do not struggle to use the pedestrian walkway, while walking speed decreases the likelihood of collisions, especially among the elderly, and provides exercise for other users.

Mohanaravi et al. (2024), discussed the challenges of using solar panels. Their study noted that while the use of solar panels is beneficial, the cost of each is very high, and also, weather, location, and land issues can diminish the effectiveness of solar panels.

Jung, (2024), showed that pavement materials affect heat, pollution, and comfort. Granite and grass pavements, as indicated in the study, can help reduce temperature and improve air quality compared to asphalt. Overall, the study demonstrates that proper slope design and solar roofs can enhance the safety and comfort of communities.

Local Study

In the study of Tan (2024), the researcher investigates the determinants influencing households' willingness to adopt Rooftop Solar Powered (RTSP) in Metro Manila and surrounding provinces, utilizing the contingent valuation method. According to the survey of Tan in particular, potential reduction in electricity was

affected by adopting RTSP Tan suggests that perceived returns on RTSP investments are insufficient to spur broader adoption without further intervention. According to Tan's study limiting only household adopting of RTSP the figure drops to 20%. This study specifies the energy reduction using the RTSP and the normal usage of electricity. In conclusion, through RTSP the users could save more energy and less expenses which could apply to sidewalk pathways for lighting purposes. Additionally, other economic advantages, such as property value appreciation and enhanced roof durability, could be emphasized in future marketing and public awareness campaigns to strengthen the case for RTSP adoption.

According to the study of Pinto (2022), it analyzed the availability and compatibility of solar and wind for placing streetlights in the stated area. The wind data were obtained from the Department of Science and Technology – Philippine Atmospheric, Geophysical, and Astronomical Services Administration (DOST-PAGASA). The pre-evaluation considerations resulted in three optimal scenarios to be compared among each other in terms of performance and output power. In conclusion, the wind speed at the said location has low contribution to the hybrid system and cannot suffice the power needed by the load. However, a solar-alone Streetlighting system is possible by considering the sunshine duration at the said Location. Though solar wind with and without inverter configuration is
costly, it only requires a small upfront investment.

Thatcher et al.(2025), emphasized that accessibility is a precondition for people with disabilities to participate fully and equally in society. Thatcher studies the

perception of disabilities in relation to accessibility. In terms of public space such as sidewalks it is just right to say that the usability of the structure and the safety of the disabilities should be prioritized in designing. The study stated the concerns of the respondents where they might choose less safe options, especially in pedestrian walkways and public infrastructure. Improving accessibility is the key for advancing a better structure where the person with disability can fully exercise their rights and live comfortably.

As stated by Castro et al. (2023), the conventional drainage system is prone to pollution and clogging; As a consequence, runoff does not drain faster, causing street floods to happen. Urban drainage networks are essential for economic development as they aid the interaction between living organisms and the water cycle by providing water supply to humans and diverting excess rainwater from the local drainage system. In conclusion, the wastewater and rainwater that contain pollutants and chemicals are prone to water ponding, flooding, and health related problems. Therefore, sustainable stormwater practices and technologies such as Low Impact Development (LID) to improve environmental quality.

According to Catubay et al.(2024), the researchers study examines public awareness, perceptions, and attitudes toward renewable energy in the Philippines. Through a survey, its results show strong support for renewable energy's environmental benefits, with 67% of respondents in favor, though 69% express concerns about high initial costs, and 57% are wary of reliability issues. Using statistical analysis, we found that age significantly affects awareness levels. In

conclusion, although the finding shows high general awareness but lack of knowledge of existing projects. In addition, according to the study there are major concerns about cost, reliability and concrete information.

Synthesis of Review in Related Literature and Studies

The review of Literature highlighted the problems that the users might encounter and its solutions in Pedestrian Walkways. Several literatures argue that Solar Radiation is one of the challenges that might encounter in pedestrian comfort. Therefore, Tomasi et al.(2023), stated that the accessibility and design of pedestrians through solar panel roofing could enhance comfort. Dellosa et al.(2021), conclude that solar panels can improve electricity consumption and enhance the aesthetics design.

Numerous studies give insight to both public health and sustainability. In a pedestrian walkway having a properly designed drainage is crucial. Kim et al. (2024), indicates that pedestrians are the most vulnerable road users to potential danger. Castro et al.(2023), on the other hand stated that sustainable stormwater practices reduce chemical and pollutant prone to ponding, flooding, and health related problems. Thus, improve environmental quality and safety.

CHAPTER 3

Research Methodology

This chapter focuses on the research methods and procedures used by the researcher to systematically address the quantitative study. It specifically discusses the research design, study respondents, sampling techniques, instruments used, including their construction, validation, administration, and retrieval as well as the statistical treatments applied for accurate data analysis and interpretation.

Research Design

The researchers used quantitative research design to collect and analyze numerical data gathered in this study. Quantitative research design was used to determine the significant effect of the design of pedestrian walkways with solar panel roofing in San Jose Del Monte National Trade School on pedestrians' safety and electricity conservation.

Design Process

Conceptualization

The pedestrian walkways design focuses on creating a safe, functional, and sustainable path for pedestrians of San Jose del Monte National Trade School. The design follows the National Building Code of the Philippines, the Accessibility Law, and the National Structural Code of the Philippines. These are vital in ensuring stability, safety, and accessibility for all users.

The design includes a solar panel roofing to supply renewable energy for lighting and small charging stations. The panels will supply electricity and promote environmental sustainability. The structure considers slope, width, and surface materials to maintain comfort and safety. Also, it has proper drainage system to prevent ponding and surface damage.

The concept emphasizes accessibility for pedestrians, ensuring their smooth flow especially in portion with different elevations. Lighting design focuses on visibility and security during nighttime. Materials were selected for durability, low maintenance, and cost efficiency. The layout aligns with the pedestrians' movement between the main road and the school entrance. This aims to promote public use, reduce road congestion, and create a clean, energy-efficient walkway for the community.

Site Analysis

The site of San Jose del Monte National Trade School in the City of San Jose del Monte, Bulacan, is assessed based on accessibility, space availability, and environmental conditions. The area lies along a busy road surrounded by schools, food stalls, and commercial establishments. This makes it ideal for a pedestrian walkway that ensures safety and order.

The assessment includes observing soil stability and drainage conditions to prevent erosion and water buildup. Accessibility is a priority to ensure students, teachers, residents, motorists and PWD can move safely between the school and nearby areas. Space utilization is planned to maintain smooth pedestrian flow and

avoid obstruction to existing structures.

Traffic circulation is also studied to reduce congestion caused by pedestrians walking on the main road. The site analysis ensures the proposed walkway will support school activities, promote safety, and be able to blend well with the environment.

User Needs

The design addresses the needs of students, teachers, residents, motorists and PWD near San Jose del Monte National Trade School by providing them a safe, accessible, and weather-protected walkway. It ensures safety through solar-powered lighting for nighttime use. The structure improves pedestrian movement, reduces traffic congestion, and follows accessibility standards to accommodate people with disabilities.

Design Tools and Software

AutoCAD is used to prepare detailed 2D layouts of the pedestrian walkway, including dimensions, elevations, and drainage layout. STAAD Pro is applied for structural analysis to test the load capacity of the walkway's roof and framing system under dead, live, and wind loads. SketchUp provides 3D visualization to present the design clearly and verify its structural arrangement. Microsoft Excel is used for cost estimation, load computation, and material quantity analysis, ensuring the design remains safe, efficient, and economical.

Sample and Population

The study focuses on the students, teachers, residents, motorists and PWD near San Jose del Monte National Trade School. These groups represent the main users of the proposed pedestrian walkway. Their feedback and experiences guide the evaluation of safety, accessibility, and functionality. The existing walkway in the area serves as the sample for analysis and design enhancement, providing a basis for applying structural design principles and sustainability features such as solar panel roofing and an improved drainage system.

Sampling Technique

The Researchers used a non-probability convenience sampling technique. As it allows data from respondents who are accessible within the study area. The respondents include the students, teachers, residents, motorist and PWD that are within the vicinity of San Jose Del Monte National Trade School. This method allows the researchers to collect data from the respondents who have direct experience with the current structure design of walkway in terms of its safety and performance.

Research Instrument

In this study, several instruments are used to gather the data needed for the design and evaluation of the proposed pedestrian walkway with solar panel roofing.

A. Designing

AutoCAD is used for detailed plans, sections, and drainage layouts, while SketchUp provides 3D visualizations for better spatial understanding. These tools help

present accurate designs that meet functional and structural requirements.

B. Surveys

Questionnaires are distributed to students, teachers, residents, motorists and PWD near San Jose del Monte National Trade School. The survey gathers feedback on safety, accessibility, comfort, and the usability of the existing and proposed walkways.

C. STAAD Pro

STAAD Pro is used to analyze and test the structural strength and stability of the walkway's roofing system. Load combinations such as dead, live, wind loads, and seismic load are applied in compliance with the National Structural Code of the Philippines (NSCP).

D. Miniature Model

A scaled model of the proposed walkway is created to represent its layout, structure, and integration of solar panels and drainage features. It provides a visual reference for evaluating design accuracy and practicality.

Data Gathering

The data collection involves four components: surveys, structural design work, miniature modeling, and costing.

The survey gathers input from students, teachers, residents, motorists and PWD near San Jose del Monte National Trade School. The questionnaire is prepared

for accuracy and clarity, focusing on safety, accessibility, lighting, and drainage issues. Surveys are conducted in person around the study area to ensure direct and reliable responses.

The structural design work collects technical data for analysis. Site observations are translated into plans using AutoCAD, while load data, including dead, live, and wind loads, are computed following the National Structural Code of the Philippines (NSCP). STAAD Pro and manual calculations are used to analyze the strength and stability of the roof and walkway structure, ensuring compliance with safety standards.

A miniature model of the proposed walkway is prepared as a scaled representation showing the layout, drainage system, and solar panel roofing. It provides a clear view of the design concept and helps validate spatial and structural details. Costing is done using Microsoft Excel to compute material quantities, labor costs, and installation expenses, confirming that the proposed design is safe, efficient, and economically viable.

Chi-Square Test

The Chi-square test is applied to determine if there are significant relationships or differences between categorical variables. It provides a statistical basis for analyzing survey data and supports validation of results.

$$x^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

Likert Scale and Weighted Mean

The Likert scale is used to measure the perceptions and opinions of respondents regarding the proposed pedestrian walkway with solar panel roofing. Questions focus on functionality, accessibility, safety, lighting, and drainage performance. The scale helps determine how respondents assess the effectiveness and sustainability of the proposed design compared to the existing walkway.

Rate	Verbal Interpretation	Range
5	Very good	4.20 – 5.00
4	Good	3.40 – 4.19
3	Acceptable	2.60 – 3.39
2	Poor	1.80 – 2.59
1	Very poor	1.00 – 1.79

Figure 2 Likert Scale

Formula:

$$Weighted\ Mean\ = \frac{\sum(f\ \times\ w\ )}{Total\ Response}$$

where:

f = frequency of each response

w = weight assigned to each response

To our respondents,

We are fourth-year Civil Engineering students from La Concepcion College, currently taking Research Writing as part of our course requirements. Our study is entitled ***"Design of Pedestrian Walkway with Solar Panel Roofing in San Jose del Monte National Trade School, City of San Jose del Monte, Bulacan."***
We respectfully ask for your cooperation in answering this questionnaire, which aims to gather your observations about the existing pedestrian walkway along the street of San Jose del Monte National Trade School.
Your responses will be treated with strict confidentiality and used only for academic purposes. Thank you very much for your time and support.

Instructions: Read each statement carefully and place a check mark (✓) in the box that best corresponds to your answer.

PART I. DEMOGRAPHIC PROFILE

Name (optional): _____

Age

☐18 below ☐19-35 ☐36-59 ☐60 and above

Gender

☐Male ☐Female

In which sector do you belong? You may check multiple answers that apply.

☐Student ☐Teacher ☐Motorist/Driver ☐Resident ☐PWD

What modes of transportation do you use?

☐Walking ☐Private vehicle ☐Public Transportation

How often do you pass by the street of National Trade School?

☐ Daily ☐ 1-2 times a week ☐ 3-4 times a week ☐ Rarely

PART II. QUESTIONNAIRE

1. **How would you describe the structural design of existing walkways along San Jose Del Monte National Trade School in terms of the following?**

SCALE 1-5 (5. Very good 4. Good 3. Acceptable 2. Poor 1, Very poor)

Safety and Accessibility	5	4	3	2	1
Presence of railings					
Anti-slip materials for surface pathway					
Slope and width of walkways					
Presence of roof					
Sufficient lighting particularly in evening					
Accessibility for people with disabilities					

Impact on Traffic	5	4	3	2	1
Avoids crowding of pedestrian on the street					
Helps pedestrian walk with ease					
Leads vehicles on proper stopping point					

2. How does the new design of a pedestrian walkway with roof and solar panel for lighting and charging station in San Jose Del Monte National Trade School be of substantial help to the community and the local government of the City of San Jose Del Monte in terms of the following?

SCALE 1-5 (5. Very good 4. Good 3. Acceptable 2. Poor 1, Very poor)

Safety and Accessibility	5	4	3	2	1
Minimize accidents					
Convenience for pedestrians and vehicle drivers					
May help reduce global warming					
Decrease electricity spending for the city					
Accessibility and safety of students, teachers, motorists, residents					
Can accommodate PWD					

Impact on Traffic	5	4	3	2	1
It will reduce traffic congestion					
Allow smooth flow of pedestrians					
Avoids illegal loading/ unloading of vehicles					

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CERTIFICATE OF VALIDATION

October 13, 2025

This is to certify that the questionnaire for the research entitled **" Design of Pedestrian Walkways with Solar Panel Roofing in San Jose Del Monte, National Trade School, City of San Jose del monte, Bulacan** has been validated as a requirement for CE Project 1. The three (3) validators can verify that the survey questionnaire was properly checked and deemed to be appropriate and useful to the research study.

Researchers

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